General Specifications for Ordinary Railroad Bridges.*

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(Concluded from page 125.)

Diameter of Rivets for Different Channels.

For attaching plates and lattice bars to channels the least diameters of the rivets to be used are to be taken from the following table; and the greatest diameters used must not exceed those given in the table, in any case, by more than one-eighth ($\frac{1}{8}$) of an inch:

Depth of Channels.	5"	6"	7"	8"	9"	10"	12"	15"
Dia. of Rivets.....	⅜"	⅝"	⅝"	⅝"	¾"	¾"	¾"	⅞"

Inclinations of Latticing and Lacing Bars.

Lattice bars shall make with each other, as nearly as circumstances will permit, angles of ninety degrees (90); and lacing bars, angles of sixty (60) degrees.

Sizes of Lattice Bars.

The minimum sizes of the lattice bars for the different depths of channels, when the distance between the inner faces of the latter does not exceed the depth, are to be taken from the following table: but if this distance exceed the depth and be less than one and a quarter times the same, either the thickness of the bars must be increased by one-sixteenth ($\frac{1}{16}$) of an inch, or their width by one-half ($\frac{1}{2}$) of an inch. If the distance between the faces be greater than one and a quarter ($1\frac{1}{4}$) and less than one and a half ($1\frac{1}{2}$) times the depth, both of these changes must be made; while, if the distance between faces be equal to or exceeds one and a half ($1\frac{1}{2}$) times the depth, the thickness must be increased by one-eighth ($\frac{1}{8}$) of an inch, and the width by one-half ($\frac{1}{2}$)of an inch. This table can be made to apply to single rivet lacing by increasing the width of the bars by three-eighths ($\frac{3}{8}$) of an inch, and making the same allowance for increased distance between faces of the channels:

Depth of Channels.	Thickness of Lattice Bars.	Width of Lattice Bars.
5"	⅜"	1⅜"
6"	⅜"	1½"
7"	⅜"	1⅝"
8"	⅜"	1¾"
9"	⅜"	1⅞"
10"	⅜"	2"
12"	½"	2⅛"
15"	⅝"	2⅝"

Built Channels.

Channels built of plates and angles are not to be less than eighteen (18) inches in depth, nor have webs less than one-half ($\frac{1}{2}$) inch thick, nor flanges less than three (3) inch by four (4) inch angles weighing thirteen pounds per lineal foot, the shorter legs to be riveted to the web. For all built channels there are to be employed, instead of the ordinary latticing or lacing bars, angle iron having dimensions not less than two (2) inches by three and a quarter ($3\frac{1}{4}$) inches by a quarter ($\frac{1}{4}$) of an inch, or weighing four and two-tenths (4 $\frac{2}{10}$) pounds per lineal foot, used as lacing bars and attached to the flanges of the built channels by two staggered rivets at each end.

Splice Plates.

The length of a splice plate is to be determined by the number of rivets necessary to transfer the stress from one main member to the other. The sum of the shearing resistances of all the rivets on either side of the joint must not be less than the stress in the main member upon that side, nor must the latter stress be greater than the sum of the working resistances at the bearing surfaces of the rivets on that side of the joint.

When practicable, a splice plate must be placed on each side of every member where a joint occurs.

The transmission of compressive stresses shall be considered as entirely through the medium of the rivets and connection plates, and these must be proportioned accordingly.

Reinforcing Plates.

Simple reinforcing plates, or plates riveted to webs at pin holes in order to compensate for strength lost there, or to provide additional bearing for the pins, must have as many rivets to attach them to the webs as will give shearing and bearing resistances for same, at least equal to the greatest allowable stresses upon the reinforcing plates.

Cover Plates.

Cover plates for top chords or batter braces are to have the same section as the chord or batter brace plate, the joints in which they cover, and enough rivets on each side of every joint to take up the greatest allowable stress that could ever come upon the cover plate.

Extension or Connecting Plates.

All extension or connecting plates on the ends of struts, for the purpose of attachment by pins of rivets, must be designed of such a strength that they could bear without buckling the greatest stress that the body of the strut could bear without rupture, and to provide enough bearing for pins and rivets. There must be a sufficient number of the latter to transfer all the stress in the post to the extension or connecting plates.

Shoe Plates and Roller Plates.

No shoe plate or roller plate is to have a less thickness than seven-eighth ($\frac{7}{8}$) of an inch.

Beam Hanger Plates.

Beam hanger plates are never to be made less than one (1) inch thick, and their areas are to be such that the hanger nuts will always have a full bearing thereon.

The necessary thickness for a beam hanger plate is to be found by considering it as a beam uniformly loaded by the whole weight that comes on the hangers to which it belongs, the length of said beam being the distance between the centres of the holes through which pass the ends of one hanger, and its width being the extreme dimension of the plate measured parallel to the floor beam. The intensity of working stress for bending in the plate is to be taken equal to that used in proportioning the floor beam.

Riveting.

In riveted work all joints are to be squarely and truly dressed, and the rivet holes must be accurately spaced.

No rivets with crooked heads or heads not formed accurately on the shank, or rivets which are loose either in the rivet holes or under the shoulder, will be allowed in a bridge.

Rivet holes in chord or batter brace plates shall be spaced as nearly as practicable three (3) inches centre to centre near the panel points, and four (4) inches centre to centre elsewhere.

No rivet holes shall be less than one and a half ($1\frac{1}{2}$) diameters from the edge of a plate, and the diameter of a hole shall never exceed that of the rivet by more than one-sixteenth ($\frac{1}{16}$) of an inch.

When two or more thicknesses of plate are riveted together in compression members, the outer row of rivets shall not be more than three (3) diameters from the side edge of the plate.

Rivet holes must never be spaced less than two and a half ($2\frac{1}{2}$) diameters nor more than six (6) inches from centre to centre.

All the rivet holes of the respective parts of any structure must be made to exactly coincide, either by drilling the holes full size through the connecting portions after being put together, or by subpunching the pieces separately and afterwards reaming the combined rivet holes to proper size. In all cases the burs must be removed by slightly countersinking the edges of the holes.

All rivets in splice or tension joints are to be systematically arranged, so that each half of a tension member or splice plate will have the same uncut area on each side of its centre line.

No rivet is to have a less diameter than the thickness of the thickest plate through which it passes, nor in any case less than half ($\frac{1}{2}$) an inch.

Use of Bolts.

The use of bolts instead of rivets is to be avoided wherever possible.

Floor Beams, Iron Track Stringers and Plate Girders.

Built floor beams, track stringers and plate girders must be well stiffened at the points of support and at several intermediate points, the distance apart of the stiffeners being made no greater than one and a half ($1\frac{1}{2}$) times the depth of the beam when the ratio of thickness of web to depth of beam is not less than one-eightieth ($\frac{1}{80}$), and no greater than the depth when this ratio is one over one hundred and twenty ($\frac{1}{120}$), distances for intermediate ratios interpolated.

Angle iron rather than tee irons are to be used as stiffeners, and are to be placed opposite to each other instead of being staggered. They must extend from the upper leg of the upper flange to the lower leg of the lower flange of the beam, being made flush with the other legs of the flanges by means of filling plates.

All built beams must be stiffened for the sake of rigidity, even if the calculated strength of the webs show that stiffeners are unnecessary.

Rivets in Flanges of Floor Beams, &c.

In spacing the rivets in the flanges of floor beams, iron track stringers or plate girders, the beam is to be divided into equal portions of about two (2) feet in length, the stresses in the flanges are to be found at the points of division, and there must be enough rivets between any consecutive points of division to take up the difference of the stresses at the points, providing that the rivets be not spaced more closely than two and a half ($2\frac{1}{2}$) diameters.

Limiting Dimensions of Webs.

No web for floor beam, track, stringer or plate girder is to have a less thickness than three-eighths ($\frac{3}{8}$) of an inch, nor a depth greater than one hundred and twenty (120) times the thickness.

Functions of Webs and Flanges.

In calculating the dimensions of a floor beam, iron track stringers or plate girder, the web must have sufficient area to take up the greatest shear, and the flanges alone must be assumed to resist the bending. The intensity of working shearing stress is to be taken equal to three and a half ($3\frac{1}{2}$) tons.

Eyes.

In welded heads, the length of metal behind the pin must be at least equal to the diameter of the pin; while in hammered heads, the amount is to be the same as that above or below the pin. The least amount of metal in the heads across the pins is given in the following table:

Width of Bar.	Diameter of Pin.	Metal in Head across Pin.	
		Welded.	Hammered.
1	0.80	1.40	1.50
1	1.04	1.50	1.50
1	1.12	1.50	1.53
1	1.20	1.50	1.56
1	1.28	1.50	1.60
1	1.36	1.55	1.72
1	1.43	1.60	1.76
1	1.50	1.67	1.85
1	1.64	1.67	1.98
1	1.77	1.70	2.05
1	1.90	1.76	2.21

In loop eyes the distance of the inner point of the loop from the centre of the pin must be not less than three times the diameter of the pin where the section of the eye is reduced to a minimum; but, if the bar be simply turned around the pin and welded, this distance, may be decreased. Pin holes in eye bars shall be bored to an exact size and distance, and to a true perpendicular to the line of stress; no error in the length of bar or diameter of pin hole exceeding one sixty-fourth ($\frac{1}{64}$) of an inch will be allowed, nor any variation of more than one thirty-second ($\frac{1}{32}$) of an inch between the centre of the eye and the centre line of the bar.

Pins.

Pins are to be proportioned to resist the bending produced in them by the bars or struts which they connect. No pin is to have a diameter less than eight-tenths ($\frac{8}{10}$) of the depth of the deepest bar coupled thereon, nor shall it vary from that of the eyes of the bars coupled thereto by more than one-fiftieth ($\frac{1}{50}$) of an inch.

Pin Bearing

Where a pin bears against a reinforced channel bar, the web of the latter is not to be assumed to take up any bearing stress, unless the reinforcing plate, or plates, be riveted to it before the pin hole be bored.

Expansion Rollers.

Expansion rollers are to be proportioned by the formula $p = \sqrt{0.135\,d}$, where p is the working load in tons per linear inch of roller, and d is the diameter of the roller in inches. The least allowable diameter for rollers is two (2) inches. The spaces between rollers must never exceed three-quarters ($\frac{3}{4}$) of their diameter.

Turn-buckles and Sleeve-nuts.

All turn-buckles and sleeve-nuts must be made so strong, that they would be able to withstand without rupture, the ultimate pull of the rods which they connect. U nuts are not to be used in any part of a bridge.

*From other selected papers of the Rensselaer Society of Engineers.

Sizes of Nuts.

The dimensions of all squares and hexagonal nuts for the various diameters of rods, are to be taken from "Carnegie's Pocket Companion" pages 130 and 131, excepting those nuts on the ends of pins, which are subject to but a slight tendency to shear the thread: in this case these dimensions may be reduced in direct proportion to this tendency, until the thickness reaches the limit of one-half ($\frac{1}{2}$) an inch. Washers and nuts must have a uniform bearing.

Jaws.

Great care must be taken, in designing jaws for the ends of any strut, that they be so strong in every respect that, when the strut subjected to its ultimate load, it will fail near the middle rather than at the ends.

Brackets.

Brackets or knees must be used to connect each upper lateral or portal brace strut to the posts or batter braces. They are to be of tee, angle or channel iron, and are to be made straight instead of curved.

Cutting off the Flanges of Channels.

The flanges at the ends of channel bars must never be cut away, if it be possible to avoid doing so; if not, there must be sufficient reinforcing used to make the strut as strong as it would have been with the flanges uncut.

Floor System.

There shall be at least four rows of track stringers in single track bridges, and six in double track bridges, one under each rail and one under each guard rail. Those under the rails shall be proportioned to carry the whole dead and live panel loads, excepting the weight of the guard rails and their stringers. Those under the guard rails shall be calculated to carry their own weight, that of the guard rails and one-half of the panel live load which comes on each truss, in order to provide for the case of a derailed locomotive, but the intensities of working stress may be increased to six (6) tons for rolled beams, five (5) tons for built beams and six-tenths ($\frac{6}{10}$) of a ton on the outer fibres, figuring on gross section, for pine or eight-tenths ($\frac{8}{10}$) of a ton for good oak.

If the stringers under the rails be of wood (an objectionable construction) they should be proportioned by the formula

$$W = \frac{b\,d^2}{c\,l^2},$$

where W= the safe uniformly distributed load in tons, b the breadth of the beam in inches, d the depth of same in inches, l the length of same in feet, and $c = 16$ for pine or 11.5 for oak. Sufficient bearing must always be provided for wooden beams in order to prevent lateral crushing of the wood, and care must be taken to see that all stringers be property supported. If the stringers rest upon the floor beams, they must be made continuous over the points of support, but must in all cases be figured as simply supported at the ends.

Where stringers rest upon the floor beams, the latter must be provided with a top plate in order to distribute the pressure.

All stringers must be so firmly fastened to the floor beams that, in case of derailment, there would be no danger of their being knocked out of place.

Bracing for Track Stringers and Plate Girders.

Plate girders and track stringers over fifteen (15) feet in length must be braced on their under sides diagonally by angle irons riveted to the flanges, and on the upper sides by dapping on the ties half ($\frac{1}{2}$) an inch.

Plate girders of twenty-five (25) feet span or over, must also have a similar diagonal bracing attached to the under sides of the upper flanges.

In all cases there must be an iron frame at each end in order to keep the two stringers properly spaced.

Ties.

Ties must be of sound oak timber, eight (8) inches by eight (8) inches in section, dapped one-half ($\frac{1}{2}$) of an inch on to the stringers, every other one being fastened down at each end by a three-quarter ($\frac{3}{4}$) inch bolt, passing through the guard rail and outer stringer, or, if the latter be of iron, through its flange. The ties are to be spaced twelve (12) inches from center to center.

Guard Rails.

Guard rails shall consist of eight (8) inch by ten (10) inch oak timbers with the longer side vertical, dapped two (2) inches on the ties, and protected on the inner upper edges by angle irons, no smaller than three (3) inches by three (3) inches by five-eighths($\frac{5}{8}$) of an inch, or weighing twelve and two-tenths ($12\frac{2}{10}$) pounds per lineal foot, well spiked to the guard rails through both legs.

For a distance of at least twenty feet from each end of a bridge, the guard rails are to be continued upon the approaches and splayed outwardly about one in ten (10) or twelve (12) in order to return to the track a derailed car or locomotive.

Details not Previously Mentioned.

Finally, as regards the proportioning of any structure, if cases should occur, which are not covered by the preceeding specifications, the following rule must in all cases be adhered to: "Details must always be proportioned so as to resist every direct and indirect stress that may ever come upon them under any probable circumstances, without subjecting any portion of their material to a stress greater than the legitimate corresponding working stress.

Cast Iron,

No cast iron is to be used anywhere, except as washers and packing washers for timber bolts.

Field Riveting.

Field riveting must be done with the button sett. The heads of the rivets must be hemispherical, and no rough edges must be left.

Painting.

All iron work is to be thoroughly cleansed (by acid or otherwise), and all scale or oxide formed in rolling is to be removed from the surface before painting. All iron work is to have one coat of metallic paint before leaving the shop, and before corrosion commences. All turned and faced parts are to receive a coat of tallow mixed with white lead before shipment.

After erection all iron work is to receive two coats of metallic paint, mixed in equal parts of parafine and linseed oil, dissolved and applied while hot.

There must be no part of the iron work inaccessible to the paint brush.

Timber.

All timber is to be of the best quality, free from wind shakes, large knots, decayed wood, sap or any other defect that would impair its strength or durability.

Quality of Workmanship.

All workmanship is to be first-class: abutting joints are to be truly planed or dressed so as to secure a perfect bearing; the pin holes in chords and posts are to be bored as truly as is specified for the eye bars; and there are no rough corners or edges to be left on the iron work.

Test of Materials.

All wrought iron is to have an elastic limit of not less than twenty-six thousand (26,000) pounds per square inch.

Full sized bars of flat, round or square iron, not over four and a half ($4\frac{1}{2}$) square inches in sectional area are to have an ultimate strength of fifty thousand (50,000) pounds per square inch, and are to stretch twelve and a half ($12\frac{1}{2}$) per cent. of the whole length.

Bars of larger sectional area than four and a half ($4\frac{1}{2}$) square inches are to be allowed a reduction of one thousand (1,000) pounds per square inch for each additional square inch of section, down to a minimum of forty-six thousand (46,000) pounds per square inch.

Specimens of a uniform section of at least one square inch taken from bars of four and a half ($4\frac{1}{2}$) square inches section and under are to have an ultimate tensil strength of fifty-two thousand (52,000) pounds per square inch and are to stretch eighteen (18) per cent. in eight (8) inches.

Similar specimens from bars of a larger section than four and a half ($4\frac{1}{2}$) square inches are to be allowed a reduction of five hundred (500) pounds per square inch for each additional square inch of section, down to a minimum of fifty thousand (50,000) pounds per square inch.

Similar sections from angle and other shaped iron are to have an ultimate strength of fifty thousand (50,000) pounds per square inch, and are to stretch fifteen(15) per cent. in eight (8) inches.

Similar specimens from plate iron are to have an ultimate strength of forty-eight thousand (48,000) pounds per square inch, and are to stretch fifteen (15) per cent. in eight (8) inches.

All iron for tension members is to bend cold, without cracking, through an angle of ninety (90) degrees to a curve, of which the diameter is not more than *twice* the thickness of the piece, and at least one sample in three is to bend one hundred and eighty (180) degrees to this curve without cracking.

Specimens from plate, angle and other shaped iron are to bend cold without cracking, through an angle of ninety (90) degrees to a curve, of which the diameter is not more than three times the thickness of the specimen.

Rivets are to be of the best quality iron, and so ductile that a bar of the diameter of the largest rivet used will bend close through one hundred and eighty degrees without sign of fracture.

Test of Structure.

On the completion of the entire structure, any bridge after being in constant use for one day, may be tested by a load equal to that for which it was designed, remaining upon it for at least one hour, without showing any permanent set.

Disinfectants.

There are many kinds of disinfectants known, and sold to the public at varying prices, some valuable, others entirely worthless, as disinfectants. Every one is familiar with bleaching-powder, which was formerly (and is still to a considerable extent) so much used. It is very effectual, owing to the chlorine gas which it freely gives off when exposed to the atmosphere, or moistened with dilute acids, such as vinegar. Charcoal, too, is well known as a disinfectant, and as a powerful deodorant. We may here remark that a deodorant simply disguises the bad smell without destroying the poison which it may contain, and in this respect differs from a true disinfectant. Of all known disinfectants, carbolic acid is now generally admitted to be the most efficacious, and it is the basis of most of the disinfecting agents now sold. The acid is too powerful to be used alone, and is therefore generally mixed with eighty or ninety per cent. of some other substance not possessed of disinfecting properties. Sometimes the bisulphites of lime and magnesia are added, and these substances are themselves possessed of disinfecting properties; but more generally chalk or sand is used; or the acid is simply diluted with water. A small portion of the mixture sprinkled in water-closets and other places where decomposing matter is allowed to remain will diminish, if not entirely remove, the chances of contagion, and sweeten and purify the atmosphere.

Although carbolic acid is so efficacious, there are some who object to its use. It smells rather strongly, and many persons are thereby prevented from using it. It is a pity on this account to be robbed of its advantages; and such persons would do well to try and educate themselves to the smell. Moreover, it is better to breathe an unpleasant and pure atmosphere than a pleasant but unhealthy and dangerous one. The smell of pure carbolic is much more easily borne than that of crude carbolic; and we would recommend the use of the purest carbolic procurable, diluted with eighty or ninety per cent. of water, or mixed with the same percentage of precipitated chalk. It is difficult for the chemist, trained and accustomed to the offensive and unwholesome smells in the laboratory, to understand how any person can retain a strong dislike to the comparatively sweet smell of carbolic acid.—*An Analytical Chemist in Cassell's Family Magazine.*

THE contract for lighting the new steel cruiser Atlanta has been awarded to the United States Electric Lighting Company of New York, and that for lighting the steel cruiser Boston to Brush Electric Company of Cleveland, O.

A CONTRACT for building the new court-house at Wichita Falls, Texas, has been let for the sum of $33,500; the building is to be completed by Nov. 1, 1885.

The Wreck of the Tardes Viaduct in France.

TRANSLATED FOR ENGINEERING NEWS FROM *Le Genie Civil.*

The railroad from Montluçon to Eygurande is located across the valley of the Tardes near Evaux, France. The gorge spanned is deep and precipitous, the distance from the rail to the surface of the water in the river being nearly 300 ft. The total length of the viaduct as projected is 821 ft. The plan included three spans, necessitating two piers 157.4 and 195.6 ft. high respectively, with two massive abutments; both piers and abutments were built of granite and the top dimensions of the piers were 14½ ft. by 26½ ft.

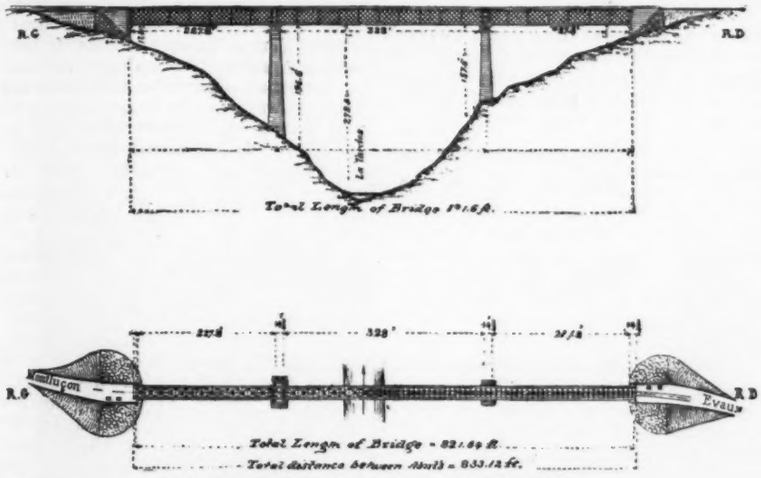

Fig. 1—Elevation and Plan of Proposed Tardes Viaduct.

The central span was 328 ft., and each side span 227.8 ft. The truss was a riveted lattice, with the bars crossing, at an angle of 45°, five times in each rectangular panel. The two trusses were 18 ft. between centres and 27.2 ft. deep.

Over the left hand pier and upon the abutments the truss was to rest upon rollers shown in Fig. 5 and upon the right hand pier upon a fixed support, as illustrated in Fig. 4. These supports were double on the piers, under each truss, the intention being to thus better distribute the weight of the central span. But owing to the very variable loads upon these supports it is now believed that this arrangement was faulty and the total strain would have been alternately on one or the other.

Method of Erection. On account of the great height of the viaduct the erection of false works was deemed impracticable and inexpedient, and the engineers determined to launch the erected truss from the shore. As shown on the plan, Fig. 1, the approache to the viaduct on both sides was on a curve, and to erect the trusses in a line with the bridge a special excavation was made in the rock on the right bank.

Three hundred and twenty-eight feet was a greater span than had ever before been launched and to diminish as much as possible the difficulties presented, a kind of pilot or false truss, 98.4 ft. long, was first erected and attached to the forward end of the central span proper; and from the river-side of the left pier a scaffolding was rigged projecting 33 ft. over the gorge. The space to be spanned was thus practically reduced to about 197 ft.

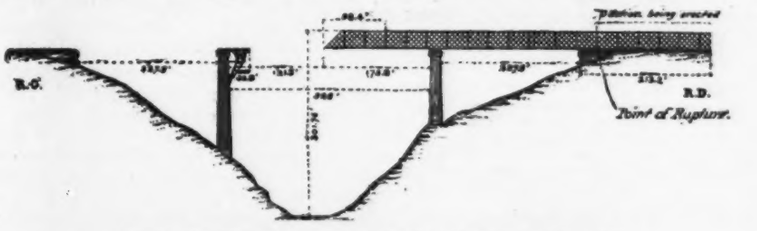

Fig. 2—Condition of the work just before the Storm of Jan. 26th.

The pilot truss was constructed of members actually belonging to the shore end of the right side span, and its weaker portions were reinforced by wooden struts.

As soon as the pilot truss and a sufficient portion of the central span proper had been erected, in the open cut, the launching was commenced upon apparatus especially designed for this purpose, and which was so located as to remain fixed until the trusses were in place.

This launching apparatus (Fig. 3) was designed by the Messrs. Eiffel & Co., and machines of the same type had been previously used by them in their practice. It may be described as follows: Upon a carriage made of plate and angle iron are two pairs of rollers, each about 20 in. in diameter, this carriage rests upon a centre about which it can freely move. In the system designed for the heavy Tardes truss, two of these roller-carriages rested upon a main carriage also of boiler-iron and also pivoted over another frame-work of iron. To increase the number of bearings, a third roller-carriage was added, as shown on the illustration, and a counterweight substituted for the fourth carriage. These various sets of rollers, owing to the general mobility of the system, readily adjust themselves to the flexure of the trusses and the variable thickness of the bottom chords, and the passing cover-plates, rivets, etc. Upon the axle of one pair of rollers in each set is a rachet wheel manipulated by a powerful wooden lever. The counter-weight attached to the third roller-carriage was increased as the load upon the system became greater, and by their action eased somewhat the strains upon the forward carriage. The engineers calculated that with a load of 13 tons upon each set of rollers the counter-weight should increase from 4,400 lbs. to 6,500 lbs., and as the greater leverage of the advancing truss threw a weight of from 28 to 30 tons on each roller-set, the counter-weight would be about 13,200 lbs.

Timber cribbing was placed between the lower frame of the launching apparatus and the pier to protect the masonry, and during the intervals of launching, timber was wedged under the bridge truss between the main rollers to sustain the weight until it was necessary to again move forward.

The Accident of Jan. 26, 1884. All work up to this date had progressed favorably and the trusses were in the position shown in Fig 2, when a sudden and violent storm occurred which caused the destruction of very nearly all the iron work erected to that time.

The forward end of the pilot-truss projected 174 ft. beyond the right pier, leaving only 121 feet between it and the scaffolding on the other pier. The bridge had been in this position only twenty-four hours before the accident occurred. It had already withstood the storm of Jan. 23 and 24 without showing any signs of weakness or change in direction, or displacement of the launching apparatus. The wreck occurred in the night, and though some of the workmen lived only a few hundred yards from the site of the bridge the accident was unknown to them until the morning. The total

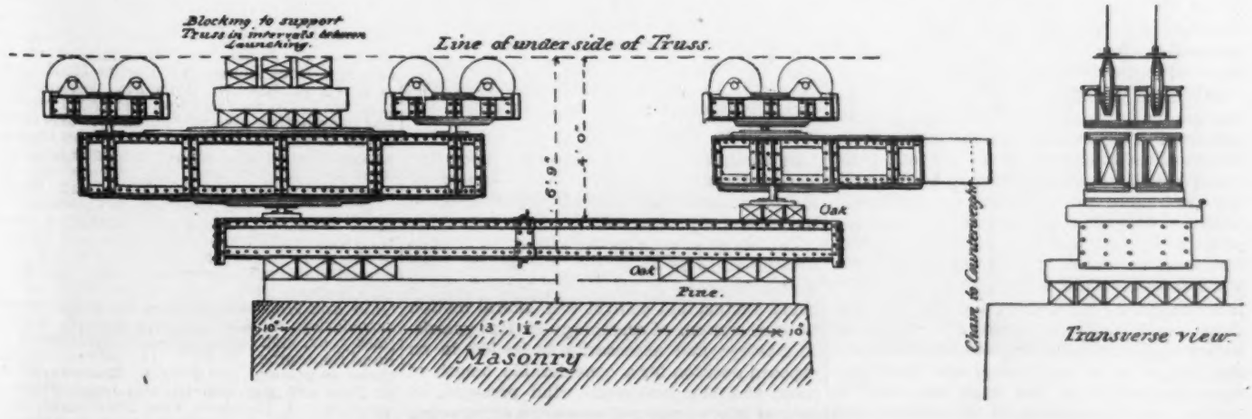

Fig. 3—Side and Transverse Views of Launching Apparatus.

length of truss destroyed was 433 ft., weighing 450 tons, the point of rupture being some distance back of the face of the right abutment. In the cut 197 ft. of erected truss was left, this portion being firmly strutted against the rocky sides of the excavation. A portion of the launching apparatus was still in place upon the pier.

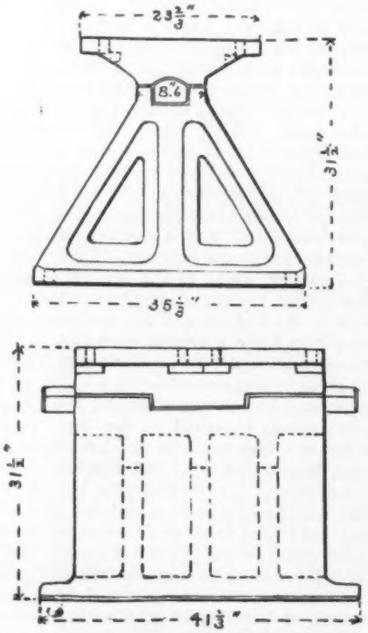

Fig. 4.—Elevation and Side View of Fixed Support on Pier.

Cause of the Accident. A number of theories have been advanced in the attempt to explain the accident. The original supposition was that the truss had been lifted bodily by a violent impulse of the storm and shifted laterally off of its supports, and consequently off of the pier. But this hypothesis does not seem admissible when we consider the great effort required to raise the heavy bridge.

The more probable theory is that the truss was gradually displaced horizontally upon its supports. The chords were resting upon the rollers of the launching frame only and these roller frames were articulated in such a manner that there was literally no anchorage whatever between the bridge and the masonry of the pier, to prevent or check lateral motion. The truss by reason of its overhang of 174 ft. was free to oscillate horizontally as a pendulum under the wind action; and these oscillations could have acquired an amplitude sufficient to gradually displace the surface of the chords from the rollers, and this once done destruction of the truss was sure to follow. An examination of the wrecked and distorted bridge members seems to bear out this last theory.

To calculate the wind force required to move and overthrow the Tardes truss under the circumstances given, the following data is necessary:

Weight of erected truss proper per lin. ft.	2.548 lbs.
Total weight of Pilot-truss	88,000 "
Total weight of truss destroyed and Pilot-truss	949,000 "

The moment of the force acting upon the pier due the overhanging portion of the bridge was thus:

$$2{,}548 \times \frac{75.44^2}{2} + 88{,}000 \times 118.08 = 17{,}678{,}073 \text{ ft. lbs.}$$

If upon the abutment the moment was zero, as we are forced to suppose, not knowing the arrangement of the timbers supporting the bridge in the cut, the reaction of the pier would be:

$$\frac{235.176 \times 2.548}{2} + \frac{17{,}678{,}073}{235.176} + 75.44 \times 2.548 + 88{,}000 = 655{,}006 \text{ lbs.}$$

To figure out the wind force oppose to the dead weight of the truss, the exposed surface of the bridge must be obtained. The determination of this surface is always a delicate task, but by adapting the latest practice we obtain a surface of 15.25 sq. ft. per lin. foot (4.65 m. per lin. metre), supposing the wind to act horizontally.

Taking the weights given above and the lever arms deduced from Fig. 2, and adopting 0.20 as the co-efficient of friction of iron upon iron as given by Poncelet, we obtain a wind pressure of 25.7 lbs. per sq. ft. as the force required to produce lateral motion of the truss upon the rollers, If the maximum co-efficient, 0.24, be taken the required wind force would be 30.8 lbs. per sq. ft. (151 kilos. per sq. metre.)

But as above calculated the surface exposed to the wind is a minimum quantity. It is more probable then that the direction of the wind was not horizontal, and any obliquity would much increase the surface acted upon by reason of the additional surface of the bottoms of the chords and the lateral bracing, the broad faces of the latter being at right angles to the axis of the truss.

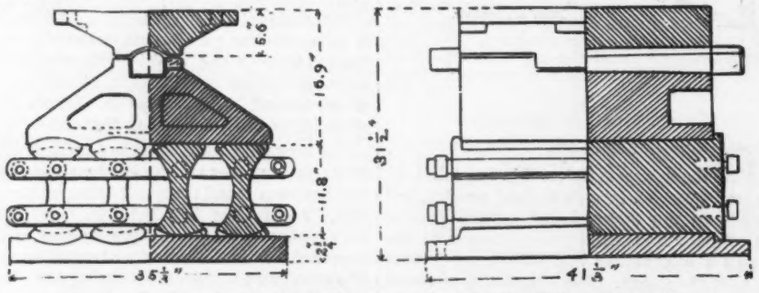

Fig. 5.—Elevation, Sectional and Side Views of the Friction Rollers on the Piers.

In both England and America the theory is pretty well established that the majority of gales of wind attack the structures from *below* and thus diminish the load upon the bridge supports. Certain accidents which have been carefully studied can only be explained by the adoption of this theory.

In summing up the reasoning upon the Tardes disaster, it seems fair to assume upon the data given, that lateral displacement of the trusses upon the rollers of the launching frame began as soon as the wind-pressure was equivalent to 26 to 31 lbs. per sq. ft. The engineers erred in not taking precautions to guard against and control this lateral motion by some system of anchorage or side guards. The bridge had necessarily to be left in an exposed position for a considerable length of time, and the maximum wind pressure, as figured above was not excessive or unusual. We know that at times wind storms may attain a velocity of 130 to 150 ft. per second corresponding to a pressure of from 40 to 50 lbs. per sq. ft. of normal surface, and this contingency should have been carefully considered by the engineers in charge.

Irrigation Works in Italy.

The irrigation system of Italy is probably the most complete in the world, and still it is constantly being increased; it forms a part of the elaborate system of defence against floods necessitated by the conformation of the Northern Provinces. According to the latest official statistics, the irrigation canals of Piedmont alone give 125,550 gallons per second, distributed over 1,340,000 acres; and those of Lombardy 95,355 gallons per second, distributed over 1,680,400 acres. These great works have not been, comparatively speaking, expensive. The Cavour canal, constructed within the last few years, draws its supply from the rivers Po and Dora Baltea. It gives a flow of 29,200 gallons per second, waters nearly 40,000 acres, and cost 1,600,000*l.*, about 32,200*l.* per mile. It was constructed in four years, and measures are now under consideration for increasing its debit by 5300 gallons per second. A smaller canal, subsidiary to it, gives 18,540 gallons per second, and cost 24,154*l* per mile. The largest canals are the Cavour, and its subsidiary canal just mentioned; the Muzza, and Agliano and Naviglio Grande. The smaller of these gives 13,200 gals. per second. Below this point the canals become very numerous, and interspersed all over the country. These canals are not only used for purposes of irrigation, but also to supply motive power, by which again the water is raised to districts lying upon a higher level. On the steep slope of the Dora Baltea, not far from Turin, three canals (the Torea, Agliano and Rotho) flow parallel to each other, on different levels, while the water is used at the top of the hill, 62 ft. above the highest of them. The arrangement adopted is as follows: A stream of 154 gallons per second is diverted from the Torea canal, and carried down the hill in a leaden pipe, until it meets the Agliano canal. Here it is pumped up to the summit level by eight pumps, worked by four turbines, driven by a fall of water taken from the Agliano canal, and allowed to flow down into the Rotho. By joining this latter it is used for irrigation, and thus not a drop is wasted. The great principle of Italian engineers is to work on a large scale, thus attaining at the same time efficiency and economy, avoiding constant alterations and additions; and it is by such means that the extraordinary fertility of Northern Italy is produced and maintained.

Road Masters' Convention.

The Roadmasters' Association of America held its second annual Convention Sept. 10th, in Indianapolis, about sixty members being present. The Association is the successor of the International Roadmasters' Association, the members of which body having disbanded at Niagara, two years ago, organized the present body in Chicago, in June of last year. J. Burnett, of Joliet, Ill., Roadmaster of the Chicago, Rock Island and Pacific Road presided. C. R. Meeker, Secretary, resigned the position some months ago, and the President has been acting also as Secretary. His report of the affairs of the latter office show that the Association enrolls eighty-five members, and forty-five applications for membership are awaiting the action of this Conve tion. Nearly every State in the Union is represented by these members, and the Roadmasters of all the great trunk lines and the greater number of the more important Western roads are included in the membership. Thomas Adamson of Lawrenceburg, Ind., Roadmaster of the Ohio and Mississippi Road, Treasurer of the association, reported: Total receipts for the past year, $372; expenditures, $161; cash on hand September 10, $211. The officers, besides those mentioned, are John C. Brennan, of the St. Paul and Minneapolis, and James Sloan, of the C. & C. I. Railroad, Vice Presidents; J. H. McDonald, W. H. Clintock and S. L. Swinney, and the President, members of the Executive Committee. The association will visit the Cincinnati Expcsition in a body on a s, ecial train over the Big Four, and thence to Louisville over the Cincinnati Southern. An interesting display of railroad appliances is made in connection with the Convention.

TARDES VIADUCT AFTER THE WRECK.

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AND

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THE attention of contractors is called to the re-advertisement and postponement of the letting of the Frankfort, Ky. Water Works, the advertisement of which may be seen on page XI. of this issue.

IN the article descriptive of the Crown Gas Pumping Engine on page 129 of our last issue, reference should have been made to the National Meter Company instead of the National Water Company.

SOME of our engineering correspondents in regions remote, enquire of us as to the benefits accruing to non-resident members of engineering societies, especially of the American Society; the requirements for membership and the annual fees.

To the first query we would answer, that association with professional men must always be beneficial even when personal acquaintance s impossible. The mere fact that a man is a worthy member of a class society will awaken ambition and excite an interest in the general progress and welfare of the profession represented that might otherwise be lacking. It will lift him out of his narrow local rut and make him acquainted, by name at least, with representative men, with whom he feels more at liberty to correspond on questions of mutual interest. The published proceedings, which cannot otherwise be obtained, contain the most valuable papers upon engineering matters made public in this country; and they furnish the best medium for the description or discussion of novel and interesting professional practice.

And last, but not least, every competent, bona-fide civil engineer should feel that to identify himself with the representative engineering society of America, is the only true method of properly guarding the rights, privileges and good name of the engineering profession. With a high standard for admission, and a rigid inspection into the qualifications of an applicant, the diploma of membership would be all the warrant required to establish the professional merit of the seeker after employment, due credit being given to the length of service and the practical experience of the applicant. The pretenders, the men who by ignorance of the principles of construction, or by lack of experience, now bring discredit upon the name they improperly and unworthily bear, would find themselves barred out, and the employers of the cheap engineer would have themselves, and not the profession at large, to blame for the usual results of their "economy."

As to the requirements for membership space will not permit our setting them out in full, but an application to John Bogart, Secretary of the American Society of Civil Engineers, No. 127 East 23rd Street, New York, will be promptly responded to, and a copy of the Constitution and By-laws no doubt fowarded, answering all questions on this head.

In answer to another query as to the whereabouts or existence of a periodical giving full reports of all meetings of the Society, with reprints of all the papers read, we can only say that there is no such publication outside of the Proceeding's and Transactions of the Society itself.

In this journal we endeavor to give a concise report of all meetings, and frequently reprint papers of general interest, but as we are limited in space many papers of great personal value never appear except in the Transactions.

So we recommend our enquiring friends to unite themselves with the Society, even though they be located "thousands of miles" from New York. The American Society of Civil Engineers is and should be a national body of professional men, and the more widely scattered its membership the better for the exhibit of general practice.

The Ead's Ship Railway.

The *London Times* of Aug. 20th contains a detailed and lengthy article upon the proposed Ship Railway across the Isthmus of Tehuantepec. We condense from it the following:

The concession from the Mexican Government was obtained by Mr. Jas. B. Eads in 1881; it extends over ninety-nine years from date; authorizes the construction of a ship railway, an ordinary railway and a telegraph line; exempts passing ships and merchandize from duty; grants 1,000,000 acres of government lands and offers protection during construction and operation.

The proposed railway will be 134 miles long from Coatzacoalcos River on the Atlantic side to Salina Cruz, on the Pacific Coast, The highest elevation above the Gulf of the proposed line will be 736 ft., the maximum gradient will be 52.8 ft. per mile, but two-thirds of the line will not exceed 26 ft. per mile.

The superstructure will include hydraulic elevators to lift the ship vertically from the water by means of a floating dock, 450 × 75 ft. by 15 ft. deep. This pontoon will sink or float in a basin prepared for it and furnished with vertical guides. On its deck are rails corresponding with the permanent way, and these rails carry the cradle on wheels to be used in transportation across the isthmus. When a ship is to be taken from the water the pontoon and cradle are sunk by admitting water, the vessel floated over them from an adjacent basin and secured over the top of the cradle; the pontoon is then pumped out and rises to the level of the rails on the land railway, and the ship and cradle started on their land journey; a reversal of this process launches it into the water on the other side.

The even distribution of the weight of the ship over the wheels of the cradle is effected by placing in the deck of the pontoon throughout its length and breadth a number of hydraulic rams. One line of these rams extends through the centre of the pontoon longitudinally, and these are designed to support the keel at points 6 ft. 9 in. apart throughout its whole length. On each side of the centre line there is arranged another shorter line of hydraulic rams, which are intended to support the bottom of the ship. On the outside of these lines are two other still shorter lines for supporting the bottom nearer to the bilges, while two other shorter lines outside these again support the bilges and sides of the vessel. There are, therefore, across the middle portion of the pontoon no fewer than seven lines of rams, while a little nearer to the bow and stern there are but five lines. Still nearer to the bow and stern there are but three lines, and, finally, the central line supporting the keel extends forward and aft of these side lines nearly the entire length of the deck. These rams are all connected together by a common system of pipes fitted with valves, by means of which they may be separated into certain groups. When the pontoon is sunk and the weight of the ship is on all these rams, if the entire system is connected together, it is evident that if there be more pressure on one ram than on another, this pressure will be equalized throughout the whole system. Mr. Eads' idea is that the ship will not be curved in the direction of her length unless the roadway gives away under her. A first-class roadway is therefore indispensable, and this having been provided, no superior longitudinal strength is required in the traveling cradle. But the weight has to be distributed over the six rails which constitute the track, the two outer ones of which are 29 ft. apart. To do this it is necessary that the traveling cradle shall be composed of strong transverse girders spaced 6 ft. 9 in. apart from centre to centre. If we suppose a 3000-ton ship upon such a cradle having thirty transverse girders spaced as above under the ship's bottom, the problem will be to cause each one of these girders to carry 100 tons, or, in other words, to transfer the excess of weight concentrated amidships to the ends of the cradle, where the vessel is lean and lacks weight. This problem is ingeniously solved by Mr. Eads in the following manner:

When the traveling cradle is run on to the pontoon each of the central girders comes exactly over seven of the rams, while the end girders have only one ram under them, as the keel only is to be carried by these girders. By making the one ram equal in area to the aggregate area of the seven rams under each central girder, it follows that the single large ram will, with the same water pressure, lift as much as the seven together, and that if they all have a common pressure the one large one will lift no more and no less than the central seven. A few of the girders nearer to the bow and the stern have only five rams under them, and these five rams have an aggregate area only equal to that of one of the larger rams.

Where the ship becomes narrower there are only three rams under each beam, the aggregate area of the three rams, however, being precisely equal to that of one of the single rams at the bow or stern, where only one support is available—namely, under the keel. Now if all these rams, with their diameters thus relatively adjusted, be forced up with a gentle pressure against the ship while she is still floating, and the water valve admitting the pressure be locked until she is lifted up by the pontoon out of the water, it is evident that her weight will be evenly distributed right away through from stem to stern—that is, every 6 ft. 9 in. each ram, and each series of rams, will hold 100 tons weight.

We have now got the weight of the ship evenly borne by the pontoon; but as she has to be run off this support on her cradle on to the railway, the next problem is to transfer

her weight from the pontoon to the cradle, so as to obviate the necessity of carrying the hydraulic rams across the country under the ship. And here another simple but very ingenious arrangement comes into operation. The heads of the rams do not come into direct contact, either with the girders of the ship, but over every ram is a vertical screw jack which passes up through the girder, and when pressure is applied by the ram the head of the jack is pushed up against the bottom of the ship. Each of the largest sized cradles will therefore be supplied with a number of screw jacks equal to the whole number of rams in the pontoon, the smaller cradles having a lesser number, and when any cradle is run on to the pontoon it is stopped and secured by a very simple looking arrangement, so that each one of the screws comes directly over a ram. The screw jack resembles nothing so much as an orchestral music stand, for it has a flat head, formed of steel plate, and which in practice would be about three feet square. This head-plate is secured on the top of the screw by means of a toggle joint, which enables the plate to adjust itself to any angle presented by the ship's side, just as the book-rest on an invalid chair can be adjusted. In order to prevent damage to the ship from abrasion, the top of the plate is cushioned with rubber or canvas, so that it perfectly adjusts itself to the curvature of the vessel. The stem of each of these screw jacks is provided with an adjusting nut, which is run up against the upper end of the screw near the plate, and when the rams are down, these nuts stop the descent of the jack by their contact with the top side of the girder on which they will rest. When the ship is floated in over the cradle, the heads of the screw jacks, with the nut beneath each, are all down resting on the platform of the cradle with their stems hanging below in the water directly over the rams. A small amount of water pressure put upon the rams raises all these screw jacks with their head-plates pressed up against the bottom of the ship and throughout the entire length of her keel. This having been done, the valve admitting water to the rams is closed, so that the water cannot escape, and the pontoon is then pumped dry and the ship raised out of the water, supported on the screw jacks, which in their turn are supported by the hydraulic system in the deck of the pontoon. In this position the nuts will be found to be at varying heights above the tops of the girders. The nuts are, therefore, screwed down with their under sides resting on the girders, which in effect constitute the platform of the cradle. The valves of the rams are now opened, and the pressure being relieved the rams retire downwards, and the weight of the ship is evenly and without alteration transferred on to the platform of the cradle.

The cradle is supported by about 360 double flanged wheels, and each of the platform girders rests upon 12 strong spiral springs and as each girder carries but 100 tons of the dead load carried on 12 wheels, each wheel carries 8¼ tons. The wheels are hung independently, each having two bearings.

The line is without curves, change of direction being accomplished by a floating turn-table consisting of a large rectangular pontoon 450 × 70 ft. by 12 ft. deep. This pontoon is placed in a segmental basin, in which it is secured over a central pivot, the water being admitted to the pontoon through this pivot which is hollow; it is also pumped out through the same opening. Rails on top of this pontoon coincide with the main line and a swing bridge is thus provided, sluice gates in the side pontoon regulating the line of flotation. When the travelling cradle with the ship on it has been run on to the pontoon the water is pumped out of it through the central joint, and is discharged into the basin until the pontoon is on the eve of floating. The pontoon is divided up into compartments by bulkheads, so that the water can be drawn from either end or either side as may be necessary to insure its being emptied evenly. In this condition it is easily moved around like an ordinary railway turn-table, but it is not necessary that it shall rise from its bearing in order that it may be revolved. By means of a small engine placed on each end of the pontoon to wind a cable made fast to the sides of the basin, the pontoon with its freight is turned around until its rails coincide with those on one of a series of radical sidings which corresponds with the altered direction of the route. When turned to the desired position the sluice gates in the pontoon are raised and the water flows back from the basin into the compartments, thus preventing the pontoon rising when the load is taken off its deck. Where streams exist on the line of route pumping engines will not be necessary to operate the floating turn-tables, as the water of such streams would be stored in reservoirs and used for this operation when needed. The water taken out of the pontoon would be run to waste through the central joint into a sluice.

Mr. Eads has introduced an ingenious device for maintaining the stability of the pontoon when under the water during the process of either being submerged to receive its load or rising to the surface with it, during the transfer of the ships from the sea to the railways. This device may be called a hydraulic governor, and consists of four pairs of hydraulic cylinders, a pair at each of the four corners of the pontoon; one cylinder of each pair having its bottom end pointing upward and the other downward, and each being secured to the side of the basin in which the pontoon works.

The cylinders are fitted with plungers which are connected with the corners of the pontoon near the deck, so that when the pontoon descends one of these plungers displaces a certain quantity of water from its cylinder. At the same time the other plunger is withdrawn from its cylinder, leaving in it a space exactly equal to the water driven out by the first plunger. The water which is displaced out of one of the cylinders at each corner of the pontoon when sinking is driven by the descending plunger into the upper cylinder at the opposite end and opposite side of the pontoon—that is, at the diagonal corner. If we suppose 100 tons more weight to be upon one end of the pontoon than on the other, this weight would rest upon the two descending plungers at that end, and would, of course, be resisted by the water in their cylinders. In the descent of these plungers this water is driven into the two upper cylinders ot the outer end of the dock, where it forces the two plungers out of those cylinders downward on to that end of the pontoon, and thus equalizes or balances the extra weight at the other end. The two sides of the pontoon are thus compelled to go down or to come up perfectly level.

The number of rails in the permanent way and the size of the traveling cradles would be varied to suit different classes of vessels. The largest cradle would be calculated to carry a ship weighing 5000 tons, this latter limit including ninety per cent. of the present gross tonnage of the world. It is estimated that five turn-tables will permit ten or twelve ships, starting from each end, to pass each other daily, and accomplish the trip in from fifteen to eighteen hours. With an average tonnage of 1500 tons each, this would amount to twenty-five per cent. more than the present traffic of the Suez Canal,

Careful estimates of the entire plant, including the handling of 5000 tons ships put the probable cost of the enterprise at $75,000,000 (£15,000,000). The motive power from ocean to ocean would be powerful locomotives running on tracks of standard gauge, the rails being so spaced.

The question of the probable strain upon the ship during the transfer has been carefully investigated, by such experts as Sir E. J. Reed, Mr. Nathaniel Barnaby, C. B., Mr. John Fowler, C. E., and others prominent in ship building and engineering circles, who unite in testifying to the feasibility of Mr. Eads' project.

PERSONAL.

The office of LT.-COL. WM. P. CRAIGHILL, U. S. Engineers, Baltimore, has been removed from 70 Saratoga Street, to 378 St. Paul Street, that city.

CHARLES SOOYSMITH, C. E., sailed on Sept. 17th, by the steamer Ems, to Bremen, to make a close personal examination into the actual working of the Poetsch Freezing Process for shaft-sinking in difficult ground. GEN. WM. SOOYSMITH & SON have arranged to purchase the right to use this process in the United States, and from the long experience and engineering ability of both father and son it could not have fallen into better hands. GEN. SMITH has been personally connected, as engineer, with nearly one half of the difficult and deep bridge foundations put down in this country, and his son has for a long time borne an active part in these same operations. The approval of the Poetsch method by these experts is warrant sufficient of its merits and its many possibilities.

LITERATURE.

The *North American Review* for October is notable as well for the importance of the topics treated, as for the eminence of its writers. The leading article, "Moral Character in Politics," is by President J. H. Seelye, whose exposition of the ethical principles involved in the popular election of candidates to high station in the Government must command the attention of every right-minded citizen. "Benefits of the Tariff System," a sequel to the article in the September number on the "Evils of the Tariff System," is a symposium consisting of three articles, written respectively by John Roach, Prof. R. E. Thompson, and Nelson Dingley, Jr., who advocate the policy of protection of American industries with great ingenuity of reasoning and abundant citations of statistical facts. In addition to these most timely discussions of high political issues, the *Review* has an article by the Rev. Dr. Augustus Jessop, entitled "Why I Wish to Visit America;" "The Philosophy of Conversion," by O. B. Frothingham; "The Origin of Yellow Fever," by Dr. C. Creighton; "Shall the Jury System be Abolished?" by Judge Robert Y. Hayne; "The Genesis of Tennyson's Maud," by Richard Herne Shepherd; and "The Development of Machine Guns," by Lieut. C. Sleeman.

The *Magazine of Art* for October contains six full-page engravings in the best style of the wood engravers' art. The frontispiece is from a painting by W. Q. Orchardson recently exhibited at the Grosvenor Gallery. It is called "The Farmer's Daughter" and is in his most attractive manner. The next page plate is a homely scene. "The Rival Grandfather's," from the painting by J. R. Reid. Lionardo's famous head of Christ is reproduced in facsimile from the original in the Brera, and is of itself worth the price of a year's subscription. There are pictures occasionally published which it is hard for the general public to understand, but the language of this portrait is unmistakable; it appeals to every one. "His Eminence's Birthday," from the painting by Frappa is of a very different class. It amuses us and that is something to be thankful for. Fennerstein's touching picture "Alsatian Pilgrims" and "The Minister's Garden" by Cecil Lawson complete the list of more important subjects of this number. The reading matter of the number is instructive and entertaining and profusely illustrated. The *Magazine of Art* has more than earned the name of "the leading Art Magazine in America." Cassell & Company (Limited) New York. Subscription $3.50 a year.

CORRESPONDENCE.

Race Course Measurement.

Special Correspondence Engineering News.

SAN FRANCISCO, Sept. 9, 1884.

EDITOR ENGINEERING NEWS: No answer having appeared to my problem of the Figure 8 Race Track published in your issue of May. 31. 1884, I herewith give the correct figures, reference being had to the letters in the diagram.

For a mile track: Radius FA, FC, JD, JB = 1.9292 chains or 325.32 feet. Length on axis EF or EJ = 11.1488 chains or 735.82 feet. Angle AEC or DEB = 52° 28' 48". For a half-mile track simply take half of above dimensions, the angle AEC or DEB of course remaining unchanged.

G. F. ALLARDT, C. E.

Irrigation in Montana.

EDITOR ENGINEERING NEWS:

From time to time I have noticed in the columns of your valuable paper extended articles upon the subject of irrigation, but nearly all of these have been in reference to works now in progress in Colorado, and, indeed, the centennial State is making rapid strides in the direction of reclaiming desert land; but I am sure that most of your readers are unaware of what has been inaugurated in Montana, the past summer, in the irrigating line.

It has lately come to be known, through the favorable results of practical experiments, that the bench lands in this northern country, with a plentiful supply of water, will raise larger and better crops of grain than the bottom lands. Hundreds of thousands of acres of these bench lands have been appropriated by stock men and there, for years, their vast herds have ranged undisturbed. But now comes the capitalist, and awakes to the fact that all of these lands may be made agricultural by the addition of water. It is by no means in all cases that the desirable combination of good lands, with plenty of water and at a reasonable rate, is to be had, and in many instances vast tracts will forever lie unproductive where it is impossible to secure the water necessary to make them profitable in an agricultural way.

It is therefore with considerable satisfaction that the enterprise, which I am about to describe to you, is regarded by those who are engaged therein, and the greatest credit is due to Mr. J. D. McIntyre, the originator of the scheme, a man who has done more towards irrigation on a large scale in Montana than any other man, in fact, he has been the one to first awaken an interest in enterprises of this kind. He is a wide-awake, pushing sort of a man, and besides this, an engineer who gained in the Black Hills an enviable reputation. He was there employed by the Black Hills Canal and Water Co., who expended under his direction over half a million dollars in canals, tunnels, covered ditches, and syphons, and the works have been in successful operation for the past six years.

Soon after coming to this country he had occasion to visit the Sun River valley, a section of country eighty miles north of Helena, and at once seized upon the idea of watering that vast tract of land lying between Sun River and the Teton, which are large tributaries of the Missouri.

For this purpose the Sun River Canal Company has been organized, a local corporation which is composed of some of our wealthiest citizens, who are determined to make it a financial success.

The ditch, or canal, to which name its size certainly entitles it, will be fifty miles in length to the point upon the high prairie or bench lands, from which by the system of laterals and side ditches the water may be distributed over the whole of some 400,000 acres of land. In addition to this there is a smaller tract of some 300 acres, which will be irrigated after twelve miles of the ditch shall have been completed.

This canal is made 15 ft. wide on the bottom, and with the embankment built on the lower side is designed to carry 5 ft. of water. The bank is set 5 ft. out from the lower edge of the ditch so that the water line on top is about 30 ft. wide. The ditch is dug 0.3 ft. deeper on the inner edge in order to throw the weight of the water away from the bank.

The grade is 2.64 ft. per mile for the first twelve miles, while for the remainder of the line it will be made 2.11 ft. per mile.

By the utilization of numerous natural reservoirs, lake basins, etc., which occur along the line, the duty of the ditch will be largely increased, and water stored during the spring for use in the dry season.

At its present size it is calculated to irrigate about 150,000 acres of the land and at no very distant day it is quite probable that the Sun River Canal will be enlarged to a size sufficient to cover the whole tract as there is an ample supply of water in the river.

It is a rapid mountain stream which heads in the main range of the Rocky Mountains, some fifty miles above where the ditch is taken out and is one of the largest tributaries of the Missouri river.

The greatest difficulties were encountered in making the surveys for this canal, but finally, after testing carefully every feasible route, the location was made of a very cheap line and work is now in progress upon the first section of eight miles, which will be completed this fall. The main ditch will cost $110,000, and the company will ultimately expend in the construction of the main canal, laterals, service ditches, and in securing lands, over $400,000, which will put it in the front rank of irrigation enterprises. Mr. McIntyre is Chief Engineer and Superintendent, and the organization of the company is due to his effort.

Mr. Frank L. Sizer, formerly of Leadville, Col., is Consulting Engineer for the company, and it was upon his report, made after a careful examination of the whole scheme, with an estimate of the cost, that the company decided upon the construction of this canal.

This enterprise has been inaugurated at an auspicious time, when all over the country there is a call for cheap lands, and it will recommend itself specially to the poorer class, who should come west and secure cheap homes before the opportunity is gone forever.

There is much to be learned in the science of irrigation, but it has been sufficiently tested in Montana to prove that our bench lands are well adapted to the raising of small grain and vegetables of all sorts as the soil is a rich, sandy loam, warmer than the soil in the bottom lands, and that crops will ripen more rapidly upon the benches, which is an important item in this northern climate.

It is probable that Montana will increase rapidly in population in the next few years as the Northern Pacific R. R. has only been completed and in operation for a little over a year, and our resources are being more thoroughly tested and the results proclaimed to the world.

Large irrigating schemes will recommend themselves to the capitalist and at the same time do more towards the development of our country than any other enterprise, giving a chance as they do to the poor to secure cheap lands. Many have anticipated the construction of this ditch by settling upon lands which are covered by it. Another large ditch is now under way on the south side of the river. The Florence Canal Co. is building it, and it will irrigate a large tract of land. Mr. McIntyre is also superintendent of this ditch and projector of the scheme. I will, at some future time, endeavor to describe this latter canal and give you such facts in relation to irrigation in Montana as I may learn from time to time.

DANIEL MARSHALL.

HELENA, MONTANA, Sept. 10, 1884.

The Forth Bridge.*

BY B. BAKER.

Two years ago I read a paper on the proposed Forth Bridge at the Southampton meeting of the British Association. Until the other day I had not since glanced at the paper, and a re-perusal was in many respects suggestive; for during the past two years the works have progressed, and some of the theories advanced in the first paper have been put to the test of actual practice. In one respect the re-perusal was a painful one, for the opening sentence contained a reference to Sir William Siemens, and I was reminded of the loss of a friend who took the greatest interest in the Forth Bridge, and whose vast experience and matured judgment could always be drawn upon in times of doubt or difficulty.

Taking up the narrative of the proceedings from the date of my last paper, I may state, in the first place, that five tenders were submitted for the construction and erection of the bridge, the amounts varying from 1,487, 000*l.* to 2,301,760*l.*, and the contract was finally let to Messrs. Tancred, Arrol, and Co., on the 21st of December, 1882, for 1,600,000*l.*, which was within 5000*l.* of the estimated cost of the work as prepared by Mr. Fowler and myself for Parliamentary purposes.

The total length of viaduct included in this contract is about 1½ miles, and there are:

2	spans of	1700	ft. each
2	"	675	"
15	"	168	"
5	"	25	"

Including piers there is thus almost exactly one mile of main spans, and half a mile of viaduct approach. The clear headway under the center of the bridge is 150 ft. above high water, and the highest part of the bridge is 361 ft. above the same datum. Each of the three main piers consists of a group of four cylindrical masonry and concrete piers, 49 ft. in diameter at the top, and from 60 ft. to 70 ft. in diameter at the bottom. The deepest pier is about 70 ft. below low water, and the rise of tide is 18 ft. at ordinary springs. In the piers there are about 120,000 cube yards of masonry, and in the superstructure about 45,000 tons of steel.

Operations were commenced in January, 1883, so the works have now been some twenty months in progress, and about 170,000*l* have been expended in plant and temporary works, and 200,000*l* in the permanent works of the bridge. At South Queensferry an area of about 20 acres of ground has been laid out in shops and yards for the manufacture of the 1700 ft. span steel girders and for other purposes. These shops are in direct communication with the North British Railway, and are connected by an incline and winding engine with a temporary timber viaduct 2200 ft. in length and 50 ft. in width, extending from the South Queensferry shore to the first of the groups of four cylindrical iron caissons which constitute the lower portions of the main piers of the bridge. At Inch Garvie, stores and offices have been built, and as this is an exposed island in the middle of the Forth the staging for the pier work is of iron pinned to the rock. Similarly at North Queensferry, on the Fife side of the Forth, stores, offices, and iron stagings have been erected.

The state of the works at the present time is as follows:

PLANT.

The plant includes 14 steam barges, launches, and other vessels; 22 steam, 12 hydraulic, and 38 hand-power cranes; 28 single and double engines for shop machines, hydraulic work, air-compressing, electric lighting, pumping, and other purposess; also gas furnaces for heating the steel plates, a 2000 ton hydraulic press for bending them, and planing machines,

*Paper read before the British Association at Montreal.

multiple drills, hydraulic rivetters, and other specially designed tools too numerous to mention. Having reference to the novelty and magnitude of the work and the amount of preliminary preparations required, it may be considered that fair progress has been made during the past twenty months.

No special difficulties were encountered in founding the viaduct piers, notwithstanding their exposed position. Except in two cases the piers rest on the rock, and they were executed in half-tide or whole tide coffer-dams, which call for no special remark. The coffer-dam for the south cantilever end pier was necessarily a very substantial structure, being a quarter of a mile from the shore. It measured 126 ft. by 75 ft. over all, and had a double row of whole timber poles, with 4 ft. of puddle between them, and internal struts, chain cable ties, and external raking struts and piles of great strength and solidity. A highly satisfactory bottom on boulder clay of rock-like hardness was found at a depth of 35 ft. below high water. The masonry of the viaduct piers and cantilever end piers consists of an Aberdeen granite facing, averaging a little over 2 ft. in thickness of rock-faced work, backed up with cement concrete or with rubble masonry set in cement, and bonded, about every 12 ft. in height, with courses of large stones carried across the entire area of the piers.

The main piers have on the whole, perhaps, given more trouble than was anticipated. On the Fife shore the whinstone rock bottom falls with a rapid slope of about 1½ to 1 to deep water, and it was necessary to step this slope for the masonry. Diamond drills worked from an iron stage were employed for the subaqueous blasting; but the removal of the rock proved a most tedious affair, and a substantial timber and clay coffer-dam had, after all, to be constructed for one of the piers. With some trouble the other pier was built within a makeshift half-tide dam, made up partly of the 60 ft. diameter permanent iron caisson below low water, with a temporary iron caisson attached to it, the whole made tight to the rock as far as might be with concrete and clay filled in between the caisson and a few buckle plates. At Inch Garvie similar delay and trouble were experienced in carrying out the shallow piers. Some of the work could only proceed at low water of spring tides, and it generally happened to blow hard just at that long waited-for moment. Tidal work, and even half-tide work, are proverbially slow and worrying; but we were all determined that, as the rock varied in quality, no foundation should be put in until the bottom had been laid dry. By perseverance and patience this has hitherto been accomplished, and we have the satisfaction of knowing that both the rock foundation and masonry are unexceptionable in strength and solidity. In our shallow rock foundations at the Forth we had much the same problem to deal with as Stephenson encountered, thirty years ago, when building the fine bridge across the St. Lawrence at this city, and our contractors dealt with it in much the same way. I am not concerned to defend the operations, as such details are usually left to those responsible, namely the contractors. Where speed is required I am satisfied that in most cases pneumatic appliances offer incomparable advantages over coffer-dam work on a rock bottom. French contractors generally resort to pneumatic caissons of ordinary type in depths exceeding 15 ft., but have employed, with great advantage, modifications known as the *caisson-batardeau*, the *bateau plongeur*, etc., in depths as little as 6 ft. The six weeks required to build a pier with the aid of pneumatic appliances may often be taken up in stopping the leaks of a coffer-dam or rock bottom. English contractors are not much accustomed to pneumatic appliances, other than an ordinary diving dress, and rarely resort to them. A diving bell with shaft of access and air lock was provided and mounted on traveller complete at the Forth, and compressed air drills were fitted in the working chamber, but no use has hitherto been made of the apparatus. The lower part of the South Queensferry main pier consists, as already stated, of a group of four pneumatic caissons 70 ft. in diameter. In the contract the option was allowed of sinking open-topped caissons by dredging inside, but, after experiencing the extreme hardness of the boulder clay, we were all agreed that it would be preferable to resort to the pneumatic process. Owing to the slope of the clay the four caissons will be sunk to varying depths, ranging from 68 ft. to 88 ft. below high water. The caissons, which were built on shore, launched and floated into position, are 70 ft. in diameter at the cutting edge, and taper 1 in 46 to facilitate sinking. At 1 ft. above low water, which is the top of the permanent caisson and commencement of the granite-faced masonry, the diameter is 60 ft. A working chamber 7 ft. high is provided at the bottom of the caisson, the roof of which is supported by four strong lattice girders 18 ft. deep, and cross girders 3 ft. deep spaced 4 ft. apart. An internal skin 7 ft. distant from the external skin, and vertical diaphragms, form pockets which can be filled with concrete at any point where, owing to the slope of the ground and the varying hardness of the silt and clay, a heavier pressure is desired to force down the caisson. Three shafts, 3 ft. 6 in. in diameter, with air locks at the top, pipes for admitting water and ejecting silt, and other of the usual appliances, are provided. The air locks for passing out the clay and boulders as designed by Mr. Arrol and myself have, instead of the usual hinged doors, two sliding doors like horizontal sluice valves, across the 3 ft. 6 in. shafts, which are worked by little hydraulic rams, or by hand, and are interlocked like railway points and signals, so that one slide cannot be opened until the other is closed. Mounted on the side of the air lock is a steam engine which, by means of a shaft passing through a stuffing-box in the side of the air lock and a drum inside, winds up the excavated material in skips containing one cubic yard. The operation of hoisting, opening slides, and discharging is rapidly performed, so the two locks have a large working capacity. A third air lock, with side doors, ladder, and hoist, is also provided for the men. The air compressing plant consists of three engines with steam and air cylinders 16½ in. in diameter by 24 in. stroke, ample power being furnished by the boilers of the locomotive type erected on the staging. Reference has already been made to the two shallow piers at Inch Garvie, but there are also two deep piers which being on a very irregular and sloping rock bottom, have required much consideration. It was finally decided to level a bed roughly with bags of sand, and to float out pneumatic caissons, and excavate the rock until a level bed was cut. Probably Mr. Fowler and I would not have adopted this precise plan if we had been contracting, although we might have resorted to the pneumatic process, but as M. Coisseau, a contractor of great experience in such work, offered to sub-contract for the sinking of the caissons at fair rates, we did not object. These caissons are 70 ft. in diameter at the bottom, and the rock slopes from 14 ft. to 19 ft. in that length, the lowest point being 75 ft. below high water.

All of the pneumatic caissons will be filled with concrete up to low-water mark, the mixture being 27 cubic feet of broken whinstone, 7 cube feet of sand, and 5½ cube feet of cement, which together make a full yard of concrete, having a crushing resistance of about 50 tons per square foot.

Above low water the cylindrical piers, which are 49 ft. in diameter at the top, 55 ft. at the bottom, and 36 ft. high, consist of the strongest masonry, the hearting being flat-bedded Arbroath stone with both horizontal and vertical bond, and the facing Aberdeen granite, the whole set in two to one cement mortar, and built in the dry within temporary wrought-iron caissons. In the shallow piers where the rock is stepped the masonry is carried down to the rock itself, and wrought-iron hoops 36 in. by 1¼ in. bind the bases of the piers. At the top of all the piers 18 in. by 1½ in. hoops, and midway down 18 in. by ¾ in. hoops, are also built in, and it is believed that these cylindrical masses of masonry are as completely monolithic as can be attained or desired. In each cylindrical pier there are forty-eight steel bolts 2½ in. in diameter and 24 ft. long to hold down the bedplates and superstructure of the main spans.

A few words now as to the manufacture of the superstructure. About 42 miles of plates have to be bent for the tubular compression members, and the best method of doing this became a question of great practical importance. Bending cold did not answer, as the true curvatures could not be so attained. Theoretically, a 10,000 ton hydraulic press would be required to bend, truly, our 16 ft. by 1¼ in. thick steel plates, and practically a 2000 ton press was of no use. Heated in a gas furnace, the plates bent readily, but distorted considerably and irregularly in cooling. Covering with ashes, packing up, and a variety of expedients were tried before the proper method was hit upon, which was to bend the plates hot and to give them a straightening squeeze afterwards when cold. Uniform heating is secured by admitting the gas near the door and midway along the furnace, and an important incidental advantage of the use of tubular compression members thus is that every plate gets relieved from any internal strains which may have been set up by shearing or improper usage at the steel works, which is of the greater moment as steel having the comparatively high tensile strength of 34 to 37 tons per square inch is used for the compression members.

Some alarm was occasioned at the works by certain 1¼ in. thick plates breaking like cast iron on being bent cold to the flat radius of 6 feet. I felt certain, however, that the Landore steel was not at fault, as our inspectors test a shearing from every plate by bending it round a radius of 1½ in. after being made red hot and cooled in water. On investigation I traced the cause of the fracture in the local damage the plates received from shearing. What the damage consists in is an unsolved riddle. It cannot extend more than $\frac{1}{16}$ in. from the edge, because planing to that extent relieves the plate and yet it effects the entire width, for the 4 ft. 6 in. plate snapped as readily as the 1 in. wide strip sheared from it. Neither can it arise from "nicking" by bad shearing, because making the plates red-hot cures the evil, though the "nicking," if previously existent, remains as visible as ever. Practically, the important point of interest to bridge builders is that with planed edges and drilled holes we have had no mysterious fractures, but the Forth Bridge plates have behaved as a material having as the higher limit a tensile strength of 37 tons per square inch and an elongation of 17 per cent. in 8 in. should behave. Our specifications for steel compression is 34 tons to 37 tons with an elongation of 17 per cent., and for steel in tension 30 tons to 33 tons with 20 per cent. elongation. The strength rarely varies as widely as the stated limits, and the elongation averages some 3 per cent. more. One of the plates which fractured from sheared edges when bent cold was tested by me in various ways. A speciman made red-hot and cooled in water at 80 degrees stood 38.3 tons per square inch and elongated 21 per cent. Another specimen made hot and allowed to cool in air stood 36.6 tons and also elongated 21 per cent., whilst one planed from the plate direct without heating failed with 34.3 tons,

but extended 25 per cent. For practical purposes, therefore, it mattered little how the plate was treated, provided the effect of the shearing was eliminated by planing or by heating.

When bent, the plates are planed at the edges in the usual way, and at the curved ends by a speciality designed radial machine. They are then, with the internal stiffeners, temporarily built into a tube round a mandrel, and drilled through plates, covers, and bars at one operation. Four specially-designed annular drill frames, surrounding the tubes, and furnished each with ten traversing drills, capable of attacking every hole, travel along lines of railway in the building yards, so laid out that four lengths of tube, each of about 400 feet, can, if desired, be dealt with at once. In a 16 feet length of 12 feet diameter tube there are about 1600 holes to drill through from 2¼ in. to 3¼ in. thickness of steel, which operation takes about fifty-two hours' working of the drills. Continuous working is, of course, not possible, as the machine has to be advanced every 8 feet which is the shift of the butts in the plating of the large tubes.

Over the piers the arched tubular lower member forms a connection with the upper bedplates, the vertical and diagonal tubes, and the lateral and vertical cross bracing, so that considerable thought had to be given to the details at this point. A full-sized model was prepared, and different modes of arranging the junctions were set out and modelled. Finally it was decided to gradually change the tubular lower member into a box form with one rounded upper corner, where it meets the skewback or part over the pier, and by internal vertical and horizontal diaphragms, to make the latter a cellular structure of enormous strength and stiffness, offering facilities for attachments in any repuire l direction. Several layers of plates form the bottom of this skewback, and constitute what may be termed the "upper bedplate" of the bridge. The "lower bedplate" consists of similar layers of plates rivetted together and bolted to the pier · and the two bedplates are free to slide on each other within certain limits to be referred to more particularly hereafter. The layers of plates run longitudinally and transversely, to meet the different stresses; and, after the edges are planed, the plates are fitted together, clamped between girders, and drilled by special machines through their whole thickness. About 1000 lineal feet of 1¼ in. holes have to be drilled in each bedplate, which in practice with the 8-drill machine, takes about eighteen days, including stoppages. In the upper bedplates holes about 11 in. square, with corners rounded to a 3 in. radius, are required, in some instances, to clear the nuts of the holding-down bolts, and these are cut readily by a simple tool devised by Mr. Arrol. In other cases, 12 feet diameter recesses, 2 in. deep, have to be bored for what may be termed a huge key or dowel, which will connect the upper and lower bedplates, but allow a slight rotation; and this also requires a special tool.

The tension members and cross bracing generally consist of box lattice girders which are drilled by traveling machines of similar type to those already referred to in connection with the tubular members. All of the rivets are of steel, having a tensile strength of about 27 tons, an elongation of about 30 per cent., and a shearing resistance of from 22 tons to 24 tons per square inch. It is hardly necessary to state that hydraulic rivetting will be used throughout. The nuts and washers of the holding-down bolts and some other parts are of cast steel, having a tensile strength of 30 tons per square inch, and an elongation of 8 to 10 per cent. It may be interesting to mention that the contractors have used steel in preference to iron in some parts of the temporary works, and that at their request the 168 feet span viaduct approach girders were changed from iron to steel with a view to save expense.

The two years' additional consideration given to this bridge since the date of my first paper has led to no modifications of importance in the design, or in the weight of steel required for the construction, a satisfactory result which is largely due to the care and ability of my colleague, Mr. Allen Stewart, who has had charge of the detailed calculations and designs from the inception of the undertaking. Originally the cantilevers had a varying batter towards each other from 1 in 7½ at the piers to vertical at the ends, where they meet the central girder. We have now made the central girders slope inwards and maintained the batter of 1 in 7½ throughout, thus getting rid of the previous "winding" which somewhat complicated the details of the cantilever, and at the same time preserving and emphasising the pyramidal form of cross-section characteristic of the design. In models of the bridge a feeling of great solidity results from this feature, as will be the case no doubt in the bridge itself, of which geometrical elevation necessarily gives but a poor idea.

We have also modified the attachment of the superstructure to the piers. Formerly the intention was to put an initial stress upon the 12 ft. tubes between the double piers as described in my first paper, and to bolt the superstructure rigidly to the masonry. Now we secure the superstructure to one only of the four cylindrical piers in each group by the great circular key already referred to, and permit a certain amount of sliding on the others. Owing to the enormous size of the structure elastic deformations which may be neglected in ordinary cases have to be provided for. A very great deal of consideration has been given to this important point, and the calculations have necessarily been complex and tedious, but we think we have now made the best disposition attainable to resist all possible and improbable hurricanes striking the bridge locally or throughout the whole span, and all variations of temperature likely to be met with at the Forth.

The question of clothing the tubes between the piers with some non-conducting material will be left for future settlement after the movements under changes of temperature have been registered by the tube itself. Fortunately, we are not troubled with Canadian variations of temperature and the correspondingly great changes of form in metallic structures. At the new Clyde Viaduct in a length of 376 ft. the observed annual range is 2 in., or a fraction over half an inch in the 100 ft., and and this is an open lattice construction, whilst the Forth Bridge horizontal members between the piers are closed tubes. Obviously during the early stages of erection, before much weight comes on the bedplates, the tube will be practically free to expand and contract. Ultimately, when the whole weight of the compl ted structure rests on the piers, the friction between the two surfaces of the upper and lower bedplates will probably be sufficient to prevent movement except under extremes of temperature and heavy wind pressure of rare occurrence. The attachment of the superstructure to the piers partakes thus of the character of a safety friction clutch. Movement will not occur under ordinary circumstances, and if an excessive shock from some unforeseen cause arise on the superstructure, it can only be transmitted to the masonry of the pier through the sliding surface of the upper and lower bedplates. Should a wave of deflection from the impact of a tornado pass along the great cantilever, as some critics suggest, then it would be arrested by skidding, as an express train is arrested, and not by running into a buffer stop.

Provision is made for lubricating the surfaces, and as the result of experiments made by myself during the past two years, probably some crude petroleum will be applied to the bedplates every time paint is applied to the rest of the bridge. Calculations have been made of the extent of sliding and of the stresses on the piers under the twisting action of a hurricane blowing on one cantilever, whilst the balancing cantilever is in a dead calm, and various coefficients of friction have been assumed. During erection sliding can, if desired, be made practically free by carrying one cantilever further out than the balancing one, and so relieving two out of the four bedplates of weight. In the completed bridge the position of the bedplates could be adjusted by temporarily loading the end of a cantilever.

Experiments on friction vary considerably, but when such large surfaces as 2,200 sq. ft., which is the joint area of the four bedplates of each main pier, are concerned, there would no doubt be an equalizing effect which would make the proper coefficient of friction for the bedplates approximate to the mean of the results obtained with a number of experiments on small areas. The co-efficients obtained by Morin for iron on iron greased ranged from .09 to .115, and with the grease wiped off, .16 to .19, the pressure being about 27 tons per sq. ft., or considerably greater than that on the Forth Bridge bedplates. On a large scale the mean values of coefficients for different surfaces are derivable from launching ways of ships, brake experiments, and other data. In launching ways the coefficient must be singularly small, for with declivities of ½ in. to 1 in. in the foot, ships not only start, but acquire a velocity of ten miles an hour or more very quickly. In some of Mr. Denny's experiments it would appear that, even with this flat slope, the velocity acquired was fully half that which a body would attain falling freely, so the retarding friction during motion must be very small. Again, the coefficient of friction at starting could not exceed .06, but, of course, in ordinary launching ways the pressure per square foot, and the character of the surfaces are different to those in the Forth Bridge, though the total weight of the moving mass may be the same, and the facts are worth mentioning on that account. Brunel's broadside launch of the Great Eastern in 1857 affords, however, valuable data directly applicable to our sliding bedplates, for the weight of the ship was 12,000 tons, and the launching ways were iron on iron somewhat rough on the surface, and imperfectly lubricated or not lubricated at all. As a a result of experiments with a small section of the launching ways, the inclination was made 1 in 12, as it was thought a small force would then start the ship, and a similar force restrain it from acquiring undue velocity, the observed coefficients of friction ranging from .125 at starting to .067 at moderate velocities. On commencing the launch an estimated force of about 500 tons was required to assist gravity on the 1 in 12 incline, hence the starting coefficient with the 12,000 ton load would be about .125 as in the model. Again, when started, the 1 in 12 was more than sufficient, for the vessel ran on some 3 ft. or 4 ft., and, spinning round the handles of the winches, injured five men. Subsequently, however, owing to want of rigidity in the ways, rusting of the rails, or some other disturbing cause, considerable trouble was experienced, and successive additions had to be made to the hydraulic presses during the three months occupied in the launch. For the last 30 ft. or 40 ft., Brunel estimated the power required, inclusive of gravity, at one-quarter of the weight, or double that which started the ship at the top of the launching ways.

Railway trains are not as heavy as ships, but afford valuable data as to the coefficient of friction of steel on steel under severe pressures, such as must obtain at the point of contact of the tyre with the rail. Captain Galton's experiments show that the coefficient varies widely with the speed and other ele-

ments, being sometimes as little as .05. With dry rails the adhesion of the driving wheels indicates a coefficient of about .20 to .25, and with wet rails, .15 to .20. Probably with "greasy" rails it would not exceed the .10 arrived at by Morin fifty years ago as an average.

Calculations of the stresses on the piers have been made upon the hypothesis that coefficients of .10 and .25 obtain on different bedplates at the same moment in the manner most unfavorable to the structure. A variety of other assumptions and test calculations have been made. As a final result we are of opinion that the maximum stress on the masonry of the main piers will be something between 9 tons and 12 tons per square foot. To attempt a closer approximation would only serve to advertise our incapacity to appreciate the complex character of the problem and the uncertainty of some of the data. So far as compression is concerned, our concrete, which has a crushing resistance of 50 tons per square foot, would thus give a factor of safety of at least four. The solid Arbroath stone piers are, of course, of far greater strength both as regards compression and the shearing and possibly tensile stresses to which the piers may be subject under the extreme hypotheses made as to force and distribution of wind.

Very valuable data as to the ability of a massive rubble pier in cement to resist a heavy lateral force were afforded by the experimental arch of 124 ft. span and 7 ft. rise built in Paris some fifteen years ago. The thrust of the arch was about 1,400 tons, and treating the abutment as an elastic solid, the stress upon the masonry would range from 14.7 tons compression to 8.7 tons tension per square foot. To ascertain the ability of cement concrete to resist heavy shearing and tensile forces I tested a number of concrete beams having different proportions of cement. Such concrete as that used at the Forth developed a tensile strength under transverse stress of about 10 tons to 12 tons per square foot, so that it was from no inherent weakness in the concrete that masonry was substituted for it in the 36 ft. upper length of the main piers. Our reason for its adoption was that we believed by using natural flat-bedded Arbroath stone set in two to one cement mortar, with both horizontal and vertical bond, we made certain of obtaining practically a monolith, whilst with concrete, however careful the inspection, there might be cleavage planes of perhaps dangerous extent in places. The special stresses on the piers arising from the cantilever system of construction have received, as I have already said, our most close consideration, and we doubt not that the desired factor of safety of four will be obtained as regards a l shearing, tensile, and compressive stresses to which the masonry may be conceived to be liable under any reasonable hypothesis which can be framed.

Happily, we are relieved from all anxiety as to the foundations, since the piers rest either on rock or on a boulder clay, which for all practical purposes is as hard as rock. It may be mentioned, however, that the heaviest load at the base of any of the 70 ft. diameter caissons, including the tilting action of a 56 lb. per square foot wind, is about 24,000 tons, or at the average rate of a little over 6 tons per square foot deducting nothing for the water displaced by the pier.

(TO BE CONTINUED.)

Note on Patching Platinum Crucibles.*

BY H. J. SEAMAN, CATASUQUA, PA.

The cost of keeping platinum ware in repair becomes such an important item in laboratories where much fusion-work is done, that a method of saving in this direction may not prove unacceptable to at least some of the members of the Institute.

Some two years since I had the misfortune to puncture an almost new Bishop crucible. As an experiment I endeavored to patch it, and with such success that it is still in constant use.

This may be accomplished in the following manner:

The crucible and patch, which should be of stout foil, are made bright with silica, or rotenstone; a light platinum wire, welded to a corner of the patch, and the whole treated for several hours with hot concentrated hydrochloric acid; after which they are thoroughly washed with distilled water and dried.

The head of an ordinary iron rivet, 4 in. by ½ in., is rounded off by hammering to somewhat the shape of the crucible. This is sunk 2 in. in a block of hard wood, and firmly wedged in place. This serves for an anvil. The hammer is an ordinary cast-iron toy, 1½ in. long, and ¾ in. in face, mounted on a ¼ in. iron rod, 10 in. long.

A gas- blowpipe is fixed in a horizontal position, and the strongest heat obtainable with it directed upon the rivet head; this soon attains a bright-red heat, and the crucible is now dropped over it. The patch, by means of the thin platinum wire, is now held over the point of operation; a few taps of the hammer serve to fix it to the crucible. The wire is now nipped off, and the patch firmly united to the crucible by continued tapping with the hammer, steadying the crucible with a platinum spatula or wire. The metal should be maintained at as nearly a white heat as possible throughout the operation. With care the metal may be so perfectly united as scarcely to show the outline of the patch. After the operation the crucible will be found very much out of shape, but it may easily be brought back by tapping with a hammer over the rounded horn of a small anvil.

I am at present using three patched crucibles; one, previously mentioned, has been in use about two years; has served for at least two hundred fusions since patching, and is still in good order. Another, which developed an extensive crack in the bottom, was repaired by a circular patch a trifle smaller than the bottom. The third has a patch on the side near the bottom. These have all done good work.

I am in the habit also of welding my platinum triangles, thereby making them light, strong, and durable.

*Read at the Chicago Meeting of the American Institute of Mining Engineers May, 1884.

THE HISTORY AND STATISTICS OF AMERICAN WATER-WORKS.

BY J. JAMES R. CROES, M. AM. SOC. C. E. : M. INST. C. E.

(*Continued from page 131.*)

DCLXXXII, DENISON, IA.

Denison, Iowa, in lat. 42° N., long., 95° 25 W' is the county seat of Crawford County.

Water-works were built by the town in 1883, after plans, and under the superintendence of G. E. Beach, the supply being taken from a well, and pumped by wind power to a tank 30 ft. in diameter and 20 ft. high, raised 40 ft. above the ground; its total elevation above the town being 125 ft.

Distribution is by one and one-half miles of cast-iron pipe of 6 in. diameter, with 14 fire hydrants and 17 taps. The cost of the works has been $11,000. The population in 1880 was 1,441. N. J. Wheeler is chairman of the Water-works Committee.

DCLXXXIII, FREDONIA, N. Y.

Fredonia, Chautauqua Co., New York, in lat. 42° 30' N., long., 79° 20' W. is built on slightly undulating table land, about three miles from Lake Erie, and is on Canadaway Creek.

Settled in 1805, it was incorporated a village in 1829. Water-works were built by the village in 1883 and 1884, after plans of Emil Kuichling, C. E. and under the direction of Geo. W. Rafter, C. E. taking the supply from the west branch of Canadaway Creek, which is fed by springs, and has a drainage area of twenty-four square miles. A stone dam, 120 ft. long, 25 ft. high and 17 ft. wide at the base, is built across the ravine through which the stream runs, and forms an impounding reservoir, holding 9,000,000 gallons, having an elevation above the village of about 240 ft. A gate house with four filtering chambers provided with screens is built, but it is not expected that filtration will be necessary. A 12-inch cast-iron pipe conducts the water three miles to the village, and it is then distributed by nine miles of cast-iron pipe of 10 to 4 in. diameter, with 56 fire hydrants and 30 gates. Service pipes are of wrought-iron and lead.

The population in 1880 was 2,692; it is now given as 3,300. The bonded debt is $85,000 at 4 per cent.

The works are controlled by a board of Water Commissioners. O. W. Johnson is President and E. A. Curtis, Secretary.

WATER.

THE Holyoke Water Power Company will probably build a new dam across the Connecticut river at Holyoke. This dam will be built just below the present one, and is estimated to cost about $2,000,000.

MARINE CITY, Michigan, has issued $40,000 worth of bonds to pay for a system of water-works. It is claimed that these are worthless however as the village charter does not authorize the council to make any such issue.

IN boring the gas well at Fort Scott, Kansas, at a depth of 625 feet, a strong stream of pure, clear, white sulphur water was struck, and on pumping out the tools the well flowed a steady stream at the rate of eight thousand gallons per day.

THE Commissioner of Public Works N. Y. will on Monday have ready for the inspection of the Aqueduct Commissioners the specifications of the work to be done in the building of the aqueduct. If these are approved the Commissioners can at once advertise for bids.

THE two Worthington pumps erected by Contractor Henry G. Morris, of Philadelphia, at the Locust Mountain Water-Works, near Centralia, Pa., will shortly be tested at their full capacity. They are of the duplex pattern with high and low pressure steam cylinders, and are said to be capable of throwing two and a half million gallons of water into the supply reservoir every 24 hours. Each pump lifts the water a distance equal to 325 feet vertical height. The new water-works will supply the borough of Centralia, Mt. Carmel, and the collieries and water tanks of the company in the vicinity.

THE Board of Experts, consisting of Messrs. Theo. J. McGowan, C. H. Wilson and J. G. Miner, to whom was referred the examination of the new pumping machinery for the city of Cincinnati, of 33,000,000 gallons capacity per diem, which has been in process of construction under the direction of Mr. Arthur G. Moore, after due examination recently, made a lengthy detailed report to the Board of Public Works of the results of their examination and tests. They received written instructions from the Superintendent of Water Works, Thomas J. Bell; also drawings and tracings representing the iron work already got out to top of masonry as far as completed. Mr. Moore stated there were no further drawings, and explained how he intended to construct the motive power. He referred the committee to the valve gear used in the Newport pumping engines, which gear he had intended to adopt. The committee found the style of valve gear used, however, to be entirely different. They found the masonry, to all appearances, first-class, the only objection being that it was not tied to the southern wall. The foundation castings, on which the pumps were to rest, were submerged, and the committee therefore could not inspect them. They find both influent valve chambers and seats of the castings at the pumping-house defective, one being cracked in nine different places; also, in the castings for stuffing box and effluent valve seats, five of the ten ribs were cracked. They procured two samples of iron from the castings mentioned, and had them submitted to a tensile strength test. Owing to defects, they were compelled to reject these castings for the purpose intended. The committee concurred with the admission of Mr. Moore that the upper portion of the effluent valve chambers were weak at the upper flange and needed strengthening. Mr. Moore proposed to make the cylinders of pumps forty inches inside diameter, with an effective stroke of thirteen feet. After a detailed consideration of the hydrostatic pressure neccessary, the report continues:

"In our opinion a serious objection arises because of the great cavity between the receiving and discharge valves, and the location of the force valve so far above the top end of the pump cylinder. In consideration of the magnitude of the power to be transmitted back and forth through the overhanging wrist-pins, we deem the construction objectionable. According to information furnished us by Mr. Moore, to wit, that he takes steam at the initial pressure of 100 pounds, and expands it twenty times, we find the engines will not have sufficient power to operate the pumps. Mr. Moore stated to us his piston speed would be 350 feet per minute to pump 33,000,000 gallons per day. We find it will be necessary to run 385 feet per minute. We deem this piston speed entirely too high for a pumping engine of so great magnitude. In answer to question No. 1, we would say the piston speed should not exceed 200 feet per minute, and that the engines should have an excess of power of at least 33⅓ per cent. over the amount necessary to move its load. In answer to question No. 2, we would say we do not deem it advisable to construct so large a single machine, but would advise the construction of three machines having a capacity of from 10,000,000 to 12,000,000 gallons each, so that in case of necessary repairs to one the public water supply would not be cut off."

Mr. McGowan orally answered some inquiries of the Board, saying if the pumping engines were constructed according to the plans of Mr. Moore, the pumps could not be started, or if started could not lift the weight required of it. The city has up to date expended $26,730 for foundation walls, $40,114 for engine and pumps, a total of $66,844 on account of this work, which will probably be condemned.—*Cincinnati Enquirer.*

NEWS OF THE WEEK.

Miscellaneous.

THE contract for driving the tunnel at Ellsworth colliery, has been awarded to James Lewis and Wm. Evans, of Minersville.

A SCHEME is on foot for constructing at Government expense a canal about eleven miles long, connecting the St Lawrence river at Longueuil with the Richelieu river at Chambly. It will reduce the water way between Montreal and New York about eighty miles for Hudson river boats.

THE dredge "H.B. Slaven," arrived at Panama on Aug. 14, last to replace the one burned some months ago. It is identical in design with the "Hercules" dredge illustrated in this journal in Jan. 1883 and was built by the American Contracting and Dredging Co., in Philadelphia.

SEALED proposals will be received at the office of the Department of City Works, Brooklyn, until Monday, Sept. 29th, for constructing sewers on Marion Street. For particulars apply at Department. Also until Friday the 26th, for sewer in Pacific Street.

SOME important orders for steel rails have recently been reported in France. The Steel Works Company of France have taken a contract for 12,000 tons from the Northern of France railway company, at £5 16s. per ton. The Southern of France railway company has let a contract to the Bouran Rolling Mills for 50,000 tons, at £5 8s. per ton.

ON Tuesday afternoon a globe valve in the service pipe leading from the New York Steam Heating Company's main into 191 Broadway, burst. A column of steam was forced by the pressure of 80 lbs. high into the air. The fracture of the valve was caused by the action of a water ram, the pipes being often cut off from the main and the steam condensing in them.

AT a meeting of the Board of County Commissioners of Alachua County, Fla., held last Thursday, the bids for building the courthouse were opened, and the contract awarded to Messrs. Murphy & Roberts, of Waycross, Ga., for the sum of $31,000. The next lowest bid was $47,000, and some were over 50,000.

THE London *Colliery Guardian* says: "It is insufficiently known that the London and Northwestern railway company are at Crewe steadily turning out Bessemer sleepers. Steel sleepers, we may add, are being made in Glasgow by Messrs. McLellan, and by the Anderton Foundry Company, for use in India and abroad, while on the Scotch lines are following the London and Northwestern, and have begun to lay down sleepers of this metal."

THE following is an abstract of the bids received by Major A. Mackenzie for dredging 20,000 yards in Rock Island Harbor, and depositing material not more than one mile distant, and for use of dredge and plant for 200 hours:

Bart E. Lenhan, Dubuque, Iowa, dredging, $4,400; dredge and plant, $1,900; total 6.300.

A. J. Whiting, Keokuk, Iowa, dredging, $2,300; dredge and plant, $2,000; total, $4,300.

H. S. Brown, Quincy, Ill., dredging. $5,000; dredge and plant $2,400; total, $7,400;

C. S. Whitney, Keokuk, Iowa, dredging, $4,600; dredge and plant, $1,600; total, $6,200.

Contract awarded to A. J. Whiting.

THE following is an abstract of the bids received by Colonel Blunt of the Corps of Engineers, for supplying 35,000 tons of rubble stone for improving Rockland Harbor:

Park & Sylvester, Boston, Mass., $1.14 per ton.

Wm. P. Hurley, Rockland, Me., $1,05.

Bodwell Granite Co., Rockwell, Me., $1.28½.

John F. Hamilton, Portland, Me., $1.06.

Thos. A. Rowe, Newton Center, Mass,, 88c.

Sargent & Hamilton, Portland, Me., $1.19.

Charles H. Edwards, Boston, Mass., $1.04

Davis Tillson, Rockland, Me., $1.20.

The contract has been awarded to Thomas A. Rowe.

THE following is an abstract of the proposals received by Colonel Poe for improving Hay Lake channel, St. Mary's River, Michigan:

John Hickler, Buffalo N. Y., 58c.

Carkins, Stickney & Cram, East Saginaw, 61c.

Williams & Upham, L'Ause, 63c.

Green Bay Dredge and Pile Driver Company, Green Bay, Wis-, 69c.

Dodge & Petri. Little Falls, N.Y., 70c.

Chicago Dredging and and Dock Company, Chicago 70c.

Fitzsimons & Connell, Chicago, 72c.

Contract awarded to John Hickler.

Omaha puts $400,000 into street paving this year.

THE contract for building the court house at Gainesville, Fla. has been awarded to Roberts & Murphy, for $31.000.

ABSTRACT of proposals received by Colonel Gillmore, of the Corps of Engineers, for improvement of the harbor at Savannah, Ga:

Rittenhouse Moore, mattresses, per sq. yard. $1.35; stone, per cubic yard, $3.40; total, $236.-750.

Wm. H. Brown, mattresses, 55c.; stone, $3.30 total, $129,350.

P. Sanford Ross, mattresses, 57c.; stone $3.30; total, $137,250.

John F. Gaynor, mattresses, 47c.; stone; $3.05; total, $119,250.

The contract has been awarded to John F. Gavnor.

THE following are the bids, as opened, for work of improving the harbor at Duluth, Superior and Grand Marias:

NAME OF BIDDERS.	Duluth. per cu. yard.	Superior. per cu. yard.	G. Marais. per cu. yard.
Chicago Dredging & Dock Co., Chicago	20 c.	20 c.	c.
Fitz. Simons & Connell, Chicago	21	21	
Williams & Upham, Duluth	14	15	25
Green Bay Dredge Co., Green Bay, Wis.	16½	16	
Truman & Cooper, Manitowoc, Wis.	15½	16½	

Williams & Upham were the successful bidders. This firm will soon begin the construction of another large dredge and several scows for the year's work. Dredging will begin immediately, and will consist of a uniform deepening of the harbor inside the present dredged area.

Railroads and Canals.

A NEW line of road will be built from Shelby, N. C., to Spartansburg, S. C.

THE Tennessee and Coosa Railroad will be built from Attalata to Guntersville, Alabama.

PANASOFEKEE, Fla,. Sept 13. The last rail to this place on the Florida Railway and Navigation Company's road was laid to-day.

THE Chicago, Freeport, and St. Paul is a line of proposed railroad which will be pushed vigorously next season. It is claimed that the line will be 50 miles shorter than any of the present lines between its termini.

THE route of the Memphis, Oxford, and Columbus roads has been surveyed between the last two places, a distance of 90 miles and the remaining 37 miles will soon be covered.

A number of capitalists among whom are Messrs. W. W. Reed and Forbes Holton, of Erie Penn, have under consideration a plan of building and operating a low grade broad gauge conecting line between Pittsburgh and Lake Erie to be built cne the line of the old Pennsylvania canal from Greenville to Erie.

ON the Magdalen branch of the Atchison, Topeka and Santa Fe. which is to run from Soccorro, N. M., west 35 miles to the Magdalen mines, seven miles of track have been laid, and work has been suspended until later in the fall. The Lake Valley branch has been built this year from Nutt, N. M., nortwest to Lake Valley, 13 miles.

SAN ANTONIO, Tex., September 10.—The San Antonio and Aransas Pass Railroad Directors put two engineering corps in the field to-day to survey a route from this place to Deep Water, on the west and east of the San Antonio River. The road will probably take the east side, by way of Goliad.

A movement has been started in the city of Marshall, Mo., by a number of capitalists to build a street railway along the principal streets in the city. The gentlemen interested in the enterprise are Thos. Boatright. Wm. M. Price, C. G. Page, Henry Strother and J. H. Cordell.

THE cable road which the Third-Avenue Railroad Company is building along Tenth Avenue and 125th Street is advancing slowly, only one of the three miles of track having been laid. The foundations of the engine-house are finished and the engines ready to ship from their place of manufacture.

The track is entirely of iron. At intervals of five feet are laid L beams for sleepers; above and bolted to these are cast-iron yokes, through which there is an opening for the conduit, and on top of which rest the rails and guards.

THE contractors on the extension of the Baltimore and Ohio Railroad to Philadelphia have received orders to put on an additional force and complete their contracts whithin the earliest possible time. Trains will be soon running between that city and Baltimore over the new line, and in order to accomplish this the work will be pushed day and night.

EXPERIMENTS with the galvanometer upon the tracks of the NewYork Central Railroads show that electric currents flow through the rails continuously. The movement is generally toward centres of electric disturbance, and is perceptibly affected by the passage of cars, fast passenger trains being much more effective than freight of coal trains. One steel rail at Rochester was so much affected by these currents as to become a permanent magnet.

VICKSBURG, Sept. 8.—A contract has been awarded to Messrs. Dunavant & Kelly, of Memphis, for the construction of the branch of the Louisville, New Orleans and Texas Railroad from Leland to a point opposite Arkansas City, a distance of twenty-two miles. By the terms of the contract this branch road is to be completed in ninety days from Sept. 4. The management contemplate constructing another branch from a point about four miles west of Leland. On the branch road mentioned above, down to Greenville and from the latter point to Lafayette and Lake Washington no contract has yet been awarded for the construction of the latter line, but it is probable that a contract for it will soon be awarded.

AT the fourth crossing of the Oregon Short Line over Snake river the masonry of the bridge is complete except one pier, and that is progressing well. The iron work is being put in place as rapidly as possible. This insures the completion of the Oregon Short Line on or before the 1st of October. The grading on the Oregon Railway and Navigation Company's line is substantially finished and track laid to within seven miles east of Baker City. They are laying track at the rate of one mile per day, and will reach Huntington, the junction of the Oregon Short Line and Oregon Railway and Navigation Company, about October 15th.

THE Mayors of New York and Brooklyn recently received copies of the following note:

MY DEAR SIR.—If the cities of New York and Brooklyn shall deem it for their best interest to sell the right to operate the railway passenger business over the East River Bridge, I am prepared, in my own behalf as well as in behalf of other responsible parties who will join me in the lease, to offer to the cities the sum of $250,000 per annum for this right for a term of twenty years, rental payable in monthly or quarterly instalments, as may be agreed. In addition to this I will agree to purchase the rolling stock at present owned by the cities at a price to be agreed upon or to be settled by appraisement, and also to keep the roadbed in as good condition as it may be at the time it is delivered to me.

To secure the payment of this rent and the performance of any agreement made on my part I will, upon the execution of such contract of and the delivery to me of the road and property, deposit with the cities the sum of $100,000 in cash or satisfactory securities and also a bond in the penal sum of $1,000,000, with securities; or, as an alternative proposition, I will pay for the use of the bridge, including all rights now belonging to the cities, the sum of $ 50,000 per annum, to be secured and payments of rental made in similar manner as before stated.

The last named proposition to cover the entire expenses incident to the management of the Bridge, with the exception of the police, which the two cities would necessarily need to control. If the cities should lease the property under either of the above propositions, I will make it a part of the contract that no tolls for passengers or teams over the Bridge shall ever be made in excess of those at present established by the Bridge trustees

(Signed)

AUSTIN CORBIN,
Pres. Corbin Banking Co.

IN the exhibition now open at Turin, the directors of the Novara and Pino Railway show the drawings and plans for the projected bridge over the Straits of Messina. The narrowest portion of the straits is 2 miles across, but the depth there is 159 m. (521½ feet), while the shallowest part, which is 110 m. (361 feet) deep, runs between Cap del Pezzo and Ganzirri. Although the distance across at the latter point is half a mile greater than at the narrowest portion of the straits, its greater shallowness has caused it to be selected as the spot for the bridge. In addition to a double line of rails, it is intended to make the bridge wide enough to include a road for ordinary carriage traffic. The viaduct will be supported by two land towers and three piers, each 1000 m. (3280 feet) apart. The foundation of the three piers will be constructed of granite ballast up to within 23 m. (75½ feet) of the surface of the water, and of granite masonry, the latter being carried to 10 m. (33 feet) above the water. The bridge will terminate on hither shore in tower-shaped piers, constructed also of granite with the ordinary dry foundations. The height of the bridge above the water will be 100 m. (328 feet.) The entire upper portion of the bridge is to be built of steel, and the construction is to be carried out in the same way as the bridge over the Mississippi at St. Louis.